RADIO ELECTRONICS
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BUILD A SYNERGY CARD FOR YOUR PC

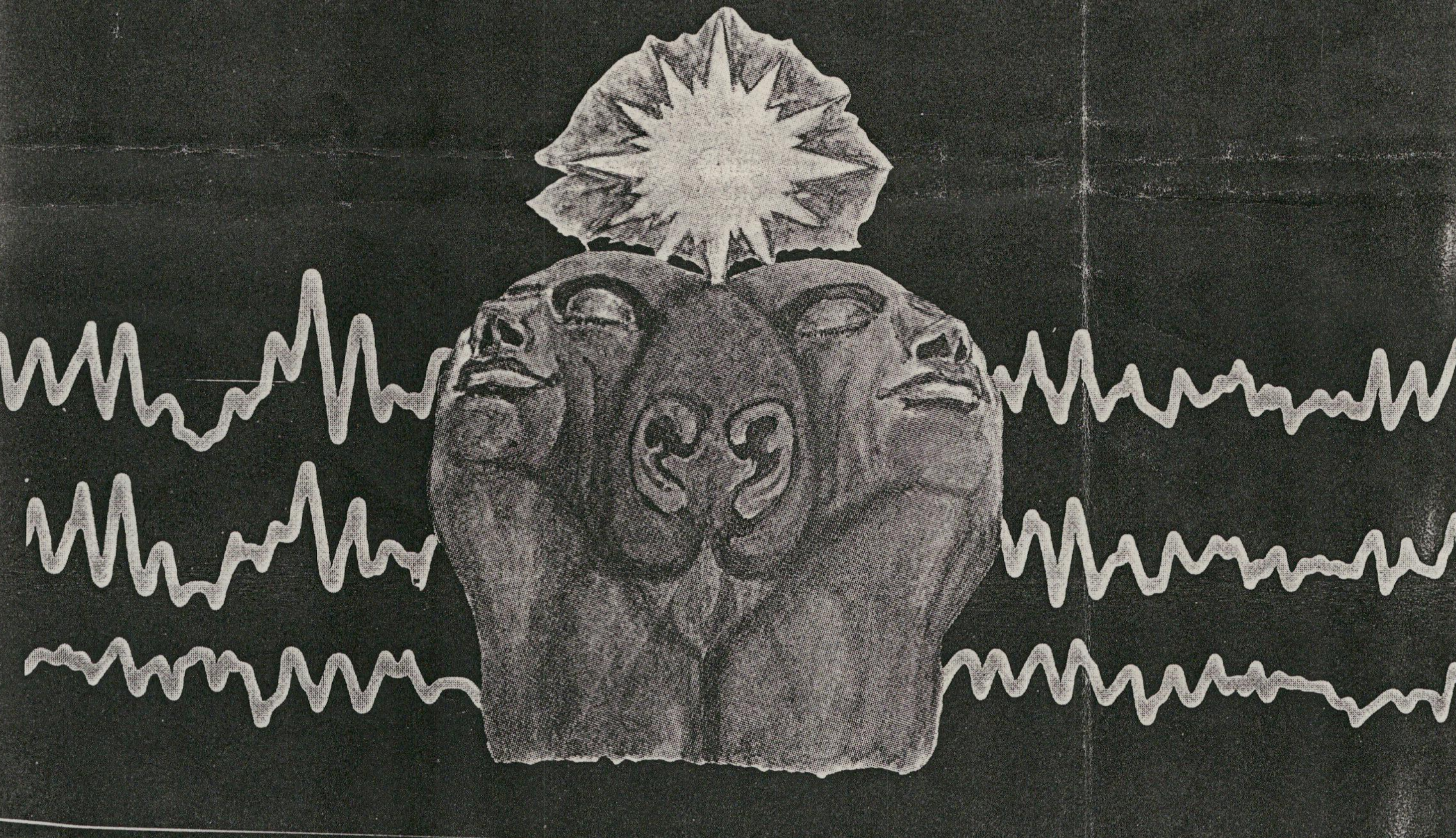
Tap your hidden potential!

Jeff Wiley & R. D. Warner

In our society, we tend to over-emphasize analytical, linear thinking, and under-emphasize intuitive, symbolic approaches. However, we short-change ourselves when we do. The best scientific achievements have something "artistic" about them, and the best artistic achievements have something "scientific" (organized or structured) about them. Systems design and analysis, for example, requires one to retain an image of the overall system while simultaneously being able to break that system down into its component parts.

To help you learn to maximize both analytical and intuitive types of skills, we're going to describe the construction of a device, called the Synergy Card, that plugs into any IBM PC or compatible with an eight-bit slot. The Synergy Card works by generating computer-controlled sound waves that put your brain into a state that is more conducive to both learning and creating. The Synergy Card can also be used to create various sound effects. The card can be built for under $100; assembled and tested versions are also available. See the sidebar for more information.

Because of the controversial nature of the technique, we'll spend most of this first article describing basic terms, background research, and philosophy. Next time we'll build the card itself and show you how to use it.



Background

Research has taught us much about how the human brain works. Using machines such as the *E*lectro-*E*ncephalo*G*raph (EEG) and the *S*uperconducting *QU*antum *I*nterference *D*evice (SQUID), researchers have discovered that there is a division of labor between the sides of the brain. The left hemisphere is predominantly analytical, linear, and verbal. By contrast, the right hemisphere is intuitive, creative, visual, and symbolic. Throughout the course of the day, we shift from one hemisphere to the other, depending on the task at hand. When speaking or balancing a checkbook, the highest brainwave amplitudes are in the left side. When painting or listening to music, the right side becomes most active.

Another discovery revealed that certain psychological and physiological states were associated with certain ranges of brain waves. That discovery led to the development of bio-feedback techniques. With the proper techniques, a person could learn to produce alpha or theta brainwaves, and thereby experience the physical and mental states associated with them.

A technique that, unlike biofeedback, requires no learning by the subject has been developed by Robert Monroe, presently of *The Monroe Institute* (TMI) in Faber, Virginia. In the late 1950's, Monroe began investigating methods of accelerated learning, which led to remarkable discoveries about the nature of human consciousness. For example, Monroe found that regular sound waves at brainwave frequencies could induce the brain to produce brainwaves of a similar frequency. That phenomenon is called a *F*requency-*F*ollowing *R*esponse (FFR). The important thing about FFR is that, given the correct frequencies, one could enjoy the physical and mental states associated with those frequencies.

Because most brainwave frequencies are quite low, "beat" frequencies are used to generate them. The way they're generated is unusual, though, because the actual beat frequencies are synthesized by the brain instead of being heard normally. To understand how it works, imagine listening through headphones to two distinct signals. A 200-Hz signal is fed to one side, and a 205-Hz signal to the other. Those signals are not being mixed electrically, nor are they mixing in the air. Nevertheless, you will hear a distinct 5-Hz beat frequency, which is created in your brain. The way it works is that the two brain hemispheres synchronize to synthesize the beat signal. That process was dubbed *Hemi-Sync* (for hemisphere synchroniztion) by Monroe. We'll call it HS.

In that example, if you were being monitored with an EEG, it would trace a 5-Hz brainwave, and the amplitudes of the signals from both hemispheres would gradually become equal.

Which signals produce desirable physiological and psychological responses? TMI was founded in 1971 to answer just that question. Thousands of experiments with volunteers led to the development of certain combinations to produce specific responses. For example, a frequency of about 4 Hz can produce theta waves, which are associated with deep relaxation and high receptivity. By itself, theta waves may produce drowsiness, but when combined with beta waves (which are associated with concentration and alert problem solving), you have an excellent mental state for learning, retention, and problem solving.

ORDERING INFORMATION

The following are available from Perceptual Research Ventures, P.O. Box 201516, Missoula, MT 59801: Etched, drilled, tin-plated, and silk-screened PC board (PR-10), $36.00; assembled, tested, and conformal-coated card (PR-48), $319.95 (for research organizations only); custom cabling (PR-8), $28.95; Sleep Lab software, compiled, runs card as a background task, leaving CPU free for other work, (PR-100), $29.95. Add $5 for postage and handling.

Case studies

A philosophy professor at the Tacoma Community College in Washington has been using HS signals combined with music in his classes since 1978. The professor spends less time on housekeeping and department tasks; students are more relaxed, cooperative, and interested in learning; and student performance is enhanced.

In another study, HS (delta, theta, and beta) was mixed with music and played in 24 second- through fifth-grade classrooms. Teachers reported that students had more highly focused attention, were more interested in learning, and were able to learn more material in a given period of time. The general classroom atmosphere was one of relaxed attentiveness.

Dream research

HS also looks useful for dream research. In fact, HS was developed mainly as a way to maintain a state conductive to lucid dreaming, so that dreaming could be studied in a more consistent manner. That fascinating phenomenon has potential as a psychological and creativity tool, and as entertainment. In fact, HS has been used to develop techniques that can teach you how to increase dream awareness, and how to dream with finesse.

Sleep research has shown that in REM sleep (the period when most dreams occur) the right hemisphere is much more active than the left. That's understandable based on what we said before, because dreams are usually pictorial, emotional, and illogical, and the right side of the brain is the home of such states.

In order to become lucid in a dream, it is necessary to increase activity in the left hemisphere. The effect of hemisphere synchronization seems to be that it allows one to carry more left-brain critical-analysis functions into dreaming. Much of what we've said about HS and dreaming is speculative, but the authors can personally attest that HS helps induce lucid dreaming.

Hardware introduction

The Synergy Card is built around two 8255A parallel interfaces, three AY-3-8910 *P*rogrammable *S*ound *G*enerators (PSG's), and a stereo amplifier suitable for driving headphones or the line-level inputs of your stereo system.

Because sound generation is done with hardware rather than software, the control software is easy to write. The hardware approach also provides much greater control over the sound envelope generated by the Synergy Card. In addition, it also frees the CPU for other tasks. For example, the CPU can give the card the necessary parameters, and then go off and monitor biofeedback equipment, altering the signal mix based on the information provided by that equipment.

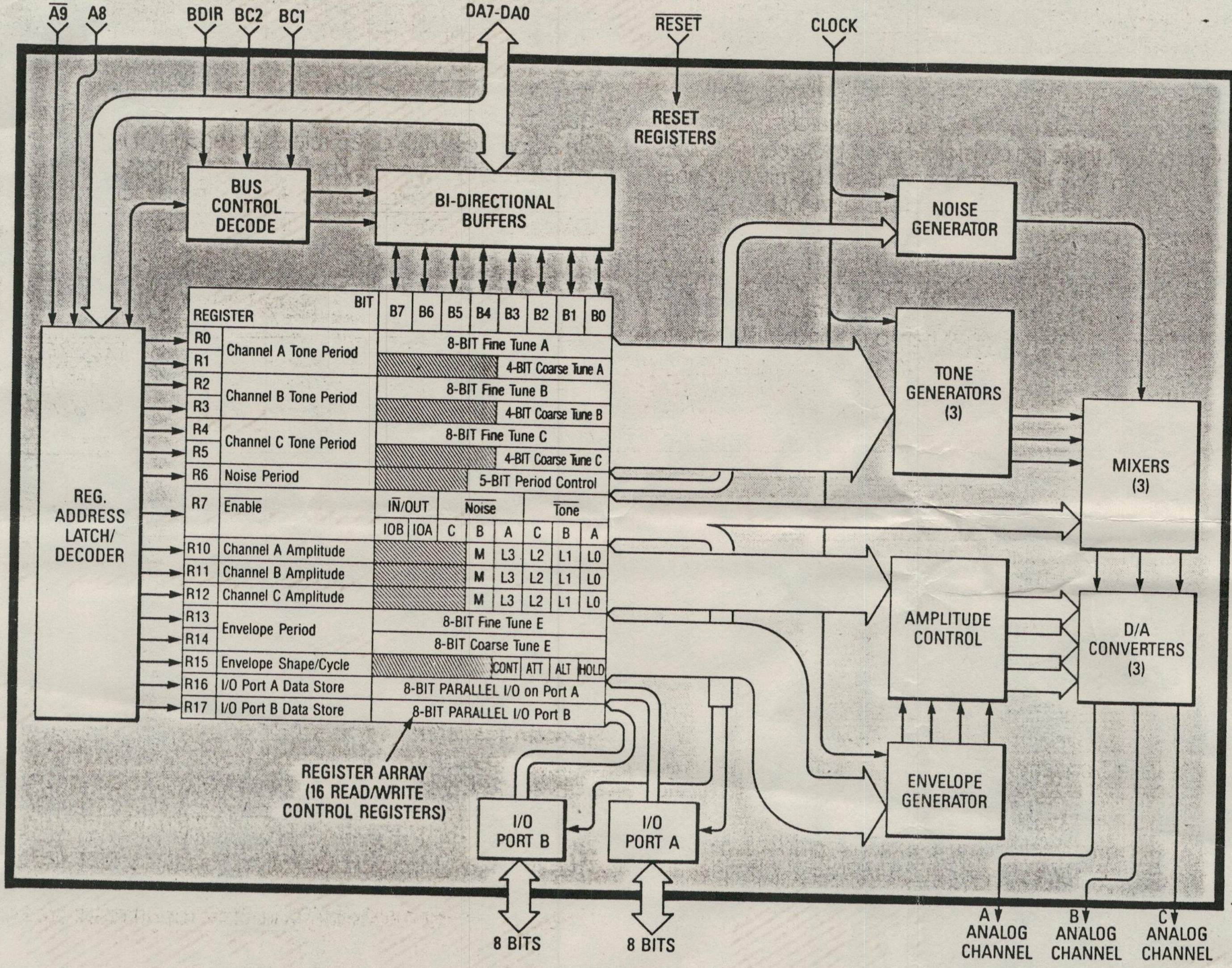


FIG. 1—THE PROGRAMMABLE SOUND GENERATOR has sixteen registers that control the operation of a noise generator, tone generators, and the frequency and amplitude of the resulting waveforms.

Figure 1 shows a block diagram of the PSG. As you can see, each PSG has three analog outputs and 16 digital I/O lines. Each of the three analog outputs has its own tone generator; the output of a single noise generator (if enabled) may be mixed with one or more outputs. The amplitude of each output may be fixed or variable, depending on the state of the envelope generator. The output of each mixer is fed through its own four-bit (sixteen-level) D/A convertor. The analog outputs of the IC have maximum amplitudes of 1 volt pk-pk.

All operational parameters are specified by a set of sixteen registers. Output frequency, for example, is determined by the contents of registers R13 and R14, which are the fine and coarse envelope period control registers. Here is the formula for determining output frequency:

$$F_O = F_C/[16 \times (256 \times C_T + F_T)]$$

F_O is the desired frequency, F_C is the clock frequency, C_T is the contents of the coarse-tune register, and F_T is the contents of the fine-tune register.

Control software must be able to calculate C_T and F_T, given a desired output frequency (F_O). (Clock frequency F_C is set at 1.8432 MHz.) For example, to obtain a 200-Hz tone, plug in the known values and re-arrange the equation as follows:

$$200 \text{ Hz} = 1843200 \text{ Hz}/[16 \times (256 \times C_T + F_T)]$$

$$200 \text{ Hz} = 1843200 \text{ Hz}/(4096C_T + 16 F_T)$$

$$4096C_T + 16F_T = 1843200 \text{ Hz}/200 \text{ Hz}$$

$$4096C_T + 16F_T = 9216$$

$$C_T = 9216/4096 = 2$$

$$F_T = 1024/16 = 64$$

C_T is calculated first, and then F_T is determined from the remainder. The reason is that the PSG views the eight-bit fine-tune register and the four-bit coarse-tune register as representing one twelve-bit number. So you really aren't solving the equation for two unknowns, but one that is broken down into most-significant and least-significant parts that fit into the two registers.

Next time we'll present the complete circuit, discuss how it works and how to build it. ◆